Designing High Energy Accelerators Under DOE's "New Culture" for Environment and Safety: An Example, the Fermilab 150 GeV Main Injector Proton Synchrotron

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Abstract

Fermilab has initiated a design for a new Main Injector (150 GeV proton synchrotron) to take the place of the current Main Ring accelerator. "New Culture" environmental and safety questions are having to be addressed. The paper will detail the necessary steps that have to be taken in order to obtain the permits which control the start of construction. Obviously these depend on site-specific circumstances, however some steps are universally applicable. In the example, floodplains and wetlands are affected and therefore the National Environmental Policy Act (NEPA) compliance is a significant issue. The important feature is to reduce the relevant regulations to a concise set of easily understandable requirements. The effort required and the associated time line will be presented so that other new accelerator proposals can benefit from the experience gained from this example.

I. INTRODUCTION

The U.S. Department of Energy (DOE) proposes to construct and operate the "Fermilab Main Injector" (FMI) accelerator, which would be a 150 GeV proton synchrotron, at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. The paper VGR 2 Achieving High Luminosity in the Fermilab Tevatron given by S.D.Holmes, describes the details of the design. Since always at the forefront in environmental issues is the "no action alternative," it seems appropriate to repeat the justification for the project.

The high energy physics program at Fermilab investigates the structure of matter using the collision of particles to create new matter. These collisions take place in the Tevatron tunnel and in the fixed target experimental areas. The FMI would provide particles for injection into the Tevatron, and for delivery to the existing fixed target experimental areas during collider operations. The FMI would permit simultaneous operation of Fermilab's collider and fixed target programs, thereby making possible an increase in Fermilab's physics output. In order for Fermilab to maintain a vital long-range colliding-beam physics program, it is necessary that the luminosity increase significantly each year so that higher energy constituent collisions can be explored. The cumulative integrated luminosity should roughly double every year in order that new physics can be explored.

In October 1989, the Director of the Office of Energy Research of the DOE asked HEPAP to offer guidance with regard to "the relative importance and appropriate balance: (a) between operations and major upgrades at a given laboratory, and (b) among the proposed major upgrades and new facilities at the various laboratories." In April 1990 HEPAP issued the report (Report of the HEPAP Sub-panel on the U.S.High Energy Physics Research Program for the 1990's). HEPAP unanimously endorsed this report at a meeting on April 23 and 24, 1990. The report says "The Sub-panel (1) strongly recommends the immediate commencement and speedy completion of construction of the Tevatron Main Injector at Fermilab... (2) The Sub-panel assigns highest priority to the first of its recommendations. The increased luminosity provided by the Tevatron Main Injector will place Fermilab in an excellent position to discover the top quark. The necessary technology for this project is firmly in hand, and a carefully considered and reliable design exists." On the basis of this recommendation, the FMI was included in the President's FY92 budget submitted to Congress on February 4, 1991.

The Fermilab's Tevatron is presently running with a peak luminosity of $2x10^{30}$. Fermilab's primary design goal is to increase the luminosity at the collider detectors by at least a factor of 30. Another goal is to increase the intensity of protons for fixed target operation by a factor of 3. Increasing the luminosity is intimately related to increasing the number of antiprotons available. Measures are currently being taken to increase the antiproton production rate by a factor of about 3. However, following implementation of these improvements, the 20-year-old Main Ring accelerator will remain the primary bottleneck restricting further production rate improvements. All of the accelerators that are involved in the production of antiprotons have significantly larger apertures than the Main Ring; therefore, the Main Ring is the bottleneck in antiproton production. The FMI would remove this bottleneck, since it replaces the old Main Ring in all of its functions, and its aperture would be matched to the other accelerators thereby assuring the achievement of a luminosity of $5x10^{31}$.

II. DOE NEPA INITIATIVE

Sensitivity to Environmental issues increased significantly with the appointment of Admiral James Watkins (Ret.) as Secretary of Energy by President Bush. In June 1989, Adm. Watkins (Ret) announced a ten-point initiative intended to strengthen environmental protection, safety and waste-management activities in the U.S.Department of Energy. In February 1990, SEN-15 was issued which clarified the NEPA (National Environmental Policy Act signed into law by President Nixon on New Years Day 1970) initiative and spelled out implementation procedures. NEPA requires review of all activities which may significantly impact the environment. This includes threatened or endangered species or critical habitats, floodplains and wetlands, and sole source aquifers. When a new construction project or a modification involves any activities with potential for environmental impact, it requires a NEPA review.

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In his February notice, Watkins reiterated how, in forming his initiatives, "I found that many of the Department's activities under NEPA had been carried out in a decentralized, non-uniform and self-defeating manner. I also state my intention to become personally involved in NEPA decision making and to ensure that NEPA actions are more closely coordinated with the governors of the states which host DOE facilities..."

"Indeed," Watkins continued, "mission goals are best served by early and adequate NEPA planning, which avoids the delays that often follow 11th-hour consideration of NEPA requirements, the resulting failure to comply fully with those requirements and, ultimately, the necessity to cure NEPA-related deficiencies before an important project may proceed. If the Department is to err in its judgment as to the extent of NEPA review required of new projects, it should err on the side of full disclosure and complete assessment of environmental impact."

III. PERMITS

Various federal environmental statutes impose environmental protection and compliance requirements that have to be adhered to. In addition there are state and local regulations that are equally important. Many of these came about as a result of NEPA, which besides setting forth a national policy for the environment, established the Council on Environmental Quality (CEQ). The CEQ issued Regulations for Implementing the Procedural Provisions of NEPA. These rules are found in the Code of Federal Regulations (40 CFR Parts 1500-1508). This is where the methodology of Environmental Impact Statements (EIS) with the final action of a Record of Decision (ROD) was established. Also, the simpler process of an Environmental Assessment followed by a Finding of No Significant Impact (FONSI) or a determination that an EIS is required was outlined.

Federal statutes that may apply to construction and operation of accelerator projects include the Clean Water Act, the Clean Air Act, the Safe Drinking Water Act, the Solid Waste Disposal Act, the National Historic Preservation Act, the Endangered Species Act, and the Farmland Protection Policy Act.

CLEAN WATER ACT - This Act makes it illegal to discharge any pollutant into any body of water, i.e. lakes, streams, wetlands, potholes, mud flats, intermittent streams, and wet meadows without a National Pollutant Discharge Elimination System (NPDES) permit. Under a new addition this will require a NPDES permit for storm water discharges by October 1991. Under Section 404 the U.S.Corps of Engineers (COE) issues permits for the filling of wetlands. The COE does not issue 404 permits unless it has received a 401 water quality permit from the state EPA. Executive orders 11988 and 11990 concern floodplain management and protection of wetlands. DOE will take action to avoid, to the extent possible, adverse impacts associated with the destruction of wetlands and the occupancy and modification of floodplains and wetlands. When this is not possible a mitigation plan will be implemented to compensate for the action.

CLEAN AIR ACT - This Act has provisions for the Attainment and Maintenance of National Air Quality Standards (NAAQS), Prevention of Significant Deterioration (PDS), and New Source Performance Standards (NSPS), which are mostly applicable to such things as dust from construction activities. Perhaps the item of significant concern for particle accelerators is the provision for the National Emission Standards for Hazardous Air Pollutants (NESHAPS).

For FMI operations, radiation doses have been calculated for normal operation losses within the operating envelope. This includes accelerator beam intensity, number of hours of operation per year, and various configurations of the experimental program. The calculations also take into account the use of the beam abort dump and above normal losses.

FMI radionuclide emissions to the atmosphere are anticipated to be 1,100 Curies/yr, and in compliance with the U.S. EPAs NESHAP (40 CFR 61 Sub-parts A and H). The off-site dose rate from Fermilab after the FMI becomes operational is estimated as 0.33 mrem/yr, well below the NESHAP standard of 10 mrem/yr. With FMI operations maximized, total yearly off-site dose from Fermilab is estimated as 1 mrem/yr.

NATIONAL HISTORIC PRESERVATION ACT - This Act requires that any project that is under consideration must take into account sites, buildings and structures that are eligible for inclusion in the National Register. DOE must afford the Advisory Council on Historic Preservation a reasonable opportunity to comment with regard to such undertaking.

ENDANGERED SPECIES ACT - This Act requires consultation with the U.S.Fish and Wildlife Service before undertaking any action to insure that the action is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of the critical habitats of such species. Accordingly, it was judged prudent to investigate whether there are any threatened or endangered species that might be affected by the proposed FMI construction. Fermilab; therefore, contracted with consultants in birds, plants, insects, amphibians, fish and mammals to conduct field surveys in the area that would be impacted by the construction.

Suitable habitat and the presence or absence of the listed species were recorded. The consultants' reports are cited in the FMI Environmental Assessment Report.

IV. CHRONOLOGY AND COST

As has been emphasized in the above it is important to start the NEPA process as early as possible; however, it is obvious that the design has to have progressed sufficiently that enough information is available that environmental studies are feasible. In the case of the FMI, this point was reached in the fall of 1989.

The FMI would be a 150 GeV accelerator with a circumference of about one-half that of the existing Main Ring. The FMI would be situated tangent to the Tevatron at the F0 straight section[1] in the southwest corner of the

[1]The Main Ring and Tevatron accelerators are designed with six straight sections, where the beam travels a short distance in a straight line, alternating with six arc sections where it follows the path of a circle with a radius of one kilometer. These 150-m long straight sections are labeled A0, B0,.....F0, and are spaced equally around the ring.

Fermilab site. The FMI would be constructed using newly designed (iron and copper) dipole magnets.

The proposed FMI, whose location is shown in Figure 1, must serve a number of purposes. It must function as a bi-directional injector into the Tevatron. This means it must be near and approximately tangent to the Tevatron. Secondly, it must receive 8 GeV protons from the Booster and 8 GeV antiprotons from the Antiproton Source. It must also provide 120 GeV protons to the antiproton target. Finally, the FMI must provide a 120 GeV beam to the present Fermilab fixed target facility hardware.

The principal housing of the FMI would utilize below grade enclosures. The FMI ring enclosure would be an oval-shaped, below grade structure, approximately 10,900' long, with a 10' wide by 8' high cross section. The floor of the enclosure would be level and at an elevation of 713'6" above sea level, 18' to 33' below existing grade. Earth shielding berms over the FMI enclosure would provide the required 21' of earth equivalent shielding.

The FMI ring enclosure would be constructed on a reinforced concrete cast-in-place (CIP) base slab. Approximately 9,900' of the ring would be built with precast concrete inverted "U" sections that would be welded to the CIP base slab. The remaining parts would be CIP.

Beginning in April 1990, $200,000 of Illinois Challenge Grant funds became available to conduct environmental studies and preliminary design. The first activity was to prepare the application for the joint permit for filling of the wetlands and the modification of the floodplain of Indian Creek. The application was submitted in September 1990.

In parallel, an Environmental Assessment (EA) was prepared which required several drafts. The submission to the environmental part of DOE occurred on April 1991. It is anticipated that if the EA is acceptable and a FONSI is sustained, then the start of construction will be October 1991 or as soon as construction funds become available. Illinois provided an additional grant of $2,000,000 in the spring of 1991 of which $500,000 was specified for environmental efforts.

Using the above plan the funds expended for the environmental effort for the FMI is estimated to be $1,400,000, since Fermilab has matched the funds of the State of Illinois as required by the terms of the Grant.

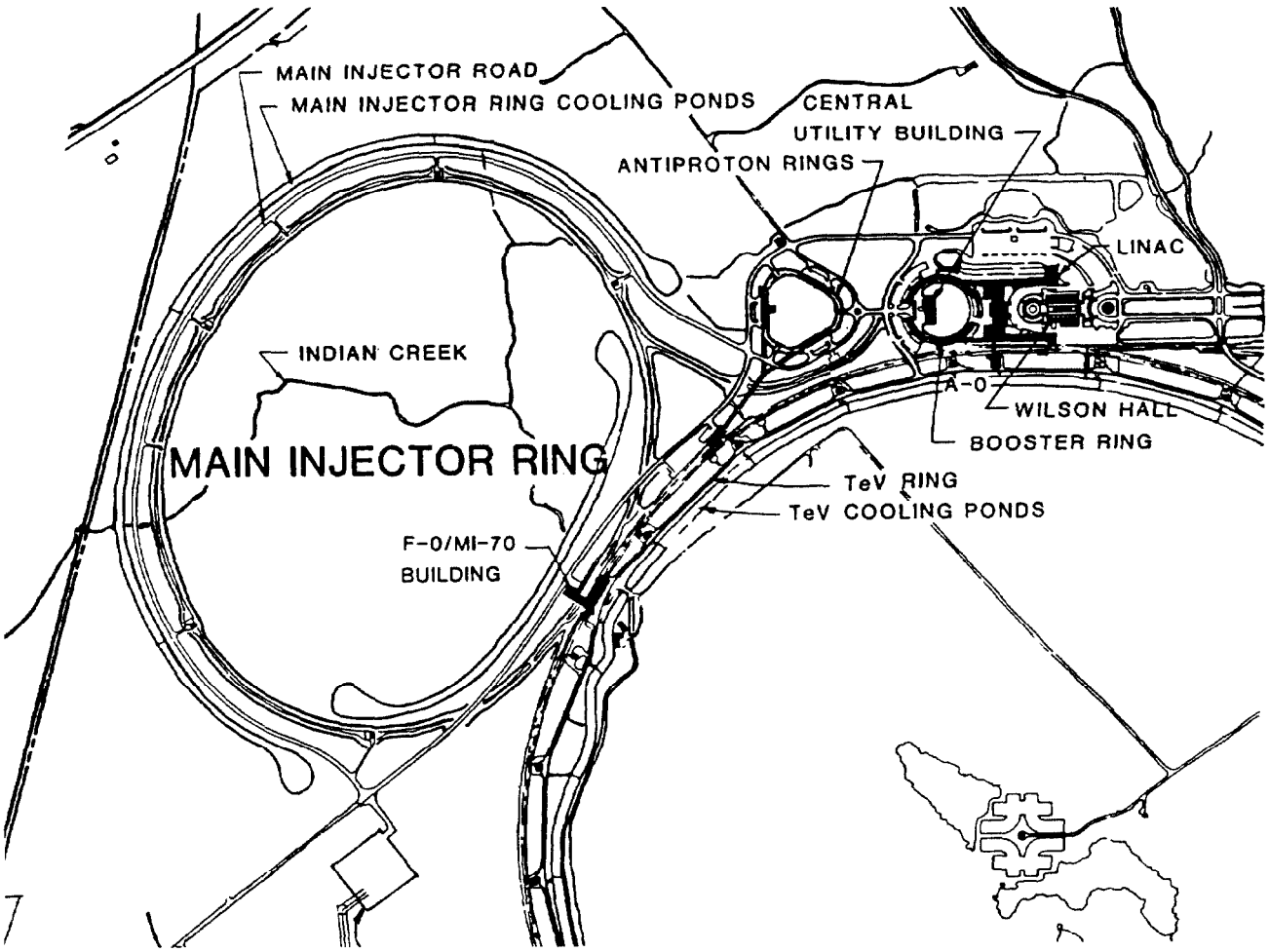

Figure 1. Fermilab Main Injector location. Indian Creek crosses the ring at several points. Approximately 100 acres of wetland is adjacent to the creek. The area of wetland that would be permanently filled has been reduced to six acres by minimizing the width of the construction at the affected areas.